Outdoor Insulation for UHVDC

By Dr. Dong Wu

abb.com/hvdc
Outdoor insulation for ±800 kVDC

- Research activity started at ABB &STRI 1992
  - With pollution test ability up to 1200 kV
  - Knowledge exchange (Cigré, IEC, other research institutes)

- First paper published here in New Delhi
  - Sept.1993 on CIGRÉ 33 Colloquium
  - More results published in 94-98
Outdoor insulation for ±800 kVDC

- Pollution test, even and uneven rain test,…
  - Station insulators up to 11 meters
  - Shed profile comparison
  - Test with and without booster sheds
  - Bushings with hydrophobic surface

- Significant operational experience reviewed and summarized
  - 1250 pole-years, 80% of DC transmitted power
  - Published in Bangalore on NPSC-2000
Known to us

- With the increasing of DC voltage
  - No trend of using longer USCD, determined by pollution

- No tendency of higher FO rate
  - Uneven wetting of wall bushing, eliminated by hydrophobic surface

- Linearity applies except low pollution area
  - Linearity: pollution withstand voltage as function of insulator length (for a given shed profile)
Known to us

- The design principle of DC outdoor insulation
  - DC/AC: pollution accumulation, shed profile
  - Coordination of internal & external insulation

- Good experience up to 600 kV

- Good experience with silicone rubber insulator
  - In North America, in China
  - Shorter USCD used (75%)
Example: Silicone rubber insulator in application

- **USA, PI project**
  - Porcelain line insulator: 35.3 mm/kV, wash every 60 days
  - Silicone line insulator: 27.1 mm/kV, no flashover
  - Porcelain wall bushing: 23.2 mm/kV, hydrophobic coating
  - Porcelain wall bushing: 500 kV, 40 mm/kV, RTV coating
  - Silicone wall bushing: 23.2 mm/kV, no flashover

- **China, in several 500 kV DC projects**
  - Porcelain line insulator: ≥40 mm/kV, clean every year
  - Silicone line insulator: 0.75 creepage, 10,000 in service, no flashover
  - Silicone wall/reactor bushings: 0.75 creepage, no flashover
Known to us

- Alternative design and alternative solutions
  - Reduced numbers of large insulator
  - Coatings, booster sheds,…
  - Indoor DC yard
- Tools for site pollution severity measurement
  - Mobile pollution test station
- Tools for overall line performance estimation
  - LPE program
No trend of using longer USCD
No tendency of higher FO rate

<table>
<thead>
<tr>
<th>Year</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td></td>
</tr>
<tr>
<td>1984</td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td></td>
</tr>
<tr>
<td>1988</td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td></td>
</tr>
</tbody>
</table>

- **No. of poles**
- **FO/year**
Linearity Applies

POLLUTION TEST RESULTS

$U_{50}(kV)$

- STRI
  - SDD = 0.02mg/cm$^2$
  - NSDD = 0.049mg/cm$^2$
- CESI
  - SDD = 0.02mg/cm$^2$
Linearity Applies
Uneven rain on DC station post

DC withstand voltage of a 5.25 meter station post insulator
under even and uneven rain

A — 230 μS/cm, higher rain intensity (≈2.4 mm/min)
B — 485 μS/cm, standard rain intensity (≈1.4 mm/min)
Alternative solutions

Number of stations

- Booster sheds
- RTV coating
- Cleaning
- Si grs coating

- No. of stations using the countermeasure
- No. of stations with flashovers in spite of the measure
800 kVDC pollution test: effect of booster sheds

![Graph showing improvement (%) vs. number of booster sheds (n).](image-url)
Way to good design and performance

- Accurate site condition specification;
- Making a reliable insulator selection and dimensioning;
- Use insulators with hydrophobic surface whenever applicable;
- Reduce the number of insulators with large diameters;
- Examine the co-ordination between the inner and outer voltage distribution for HVDC apparatus;
- Choose the suitable monitoring and maintenance methods when it is necessary;
- Indoor DC yard if necessary.